

Arto V. 6.

OBSERVATIONS

ON THE EFFECTS

WHICH CARRIAGE WHEELS,

WITH RIMS OF DIFFERENT SHAPES,

HAVE ON THE ROADS;

RESPECTFULLY OFFERED TO THE CONSIDERATION

OF THE LEGISLATURE.

BY

ALEXANDER CUMMING, F.R.S. ED.

AUTHOR OF THE ELEMENTS OF CLOCK AND WATCH-WORK.

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TO THE READER.

LATE in the last Session of Parliament, Mr. Cumming had occasion to attend a Committee of the House of Commons, then deliberating on the means of relieving Carriages of a certain description from the controul of Weighing Engines, and subjecting them to an additional Toll, in compensation; and being asked his opinion as to the equivalency of the additional Toll proposed, to the damage which the Roads would sustain by the exemptions, he stated as his opinion, "That the damage would chiefly depend on the construction of the wheels that were used; that the Conical or Tapering Rims now universally used, were extremely destructive; and that a flat Cylindrical Rim would be very advantageous to the Roads." But being then unprepared, and judging that what he might have to say on the subject, would be too long for their Report, he declined entering more fully upon the subject. But the high respect due to the Legislature, and an earnest desire of contributing all in his power to the accommodation of the Public, induced him to the investigation that composes the following Essay; and if it should by some be thought too prolix let it be imputed to a desire of overcoming prejudices established by long and universal usage; by representing the object in various lights.

But Seeing as he proceeded that a large field of inquiry presented itself, and that his Essay was extending beyond the intended limits: he found it necessary to confine his observations as much as possible to the immediate and contrary effects which the Conical and the Cylindrical Rims of Broad Wheels must have upon the Roads.—In that light therefore, the following
Essay

Essay is offered—not as treating generally of the construction of Wheels or Wheel Carriages.

And although very great advantages may be gained by an immediate adoption of Cylindrical Rims, more especially to the Broad Wheels of heavy Carriages, yet many regulations will be necessary to extend these advantages to the utmost limits of which they are susceptible, and to diffuse the effects of Cylindrical rolling, more equally than at present, over the whole surface of the Roads.

Much may be done by illustrating, by the most familiar means, the several properties and effects of the Conical and Cylindrical Shapes; and contrasting them by simple experiments and ocular demonstration.—It will also be necessary that Owners of Waggon be fully informed of all such matters, and of the privileges and exemptions to which a compliance with the new regulations would entitle them; and that all those employed in building heavy carriages, be made acquainted with the best principles, and most approved Construction; by which means, the profound judgment of Men of Science, and the practical knowledge and dexterity of the Artist, may be united for the public good:—and probably a system might be adopted which would effectually answer all those purposes, without additional expence to the public.

N. B. The numbers enclosed in parenthesis () refer to the preceding paragraphs on which the subject matter of the present more immediately depends.

PENTONVILLE,

1797.

OBSERVATIONS,

Ec. Ec.

- 1.—ALTHOUGH the following observations are applicable to wheels of every denomination, they more particularly apply to the broad wheels of Waggon, and other heavy Carriages, because in them the effect is greater and more perceptible.
- 2.—The properties of all wheels, so far as regards this inquiry, depend upon their affinity to the Cylinder, or to the Cone: and, in order to shew the nature and tendency of each class, it is necessary briefly to state such properties as unavoidably arise from the shape of these bodies.
- 3.—THE CYLINDER, having *all its parts of equal diameter*, will, in rolling on its rim, have *an equal velocity at every part of its circumference*, and *necessarily advance in a straight line*.
- 4.—And as all the parts of the rim have an equal velocity, none can have a tendency to drag forward, or to retard the progress of the others: they all advance with one consent, without the rubbing of any part on the surface on which they roll.
- 5.—As there is no rubbing, there can be no friction; and consequently, a Cylinder perfectly round, hard, and smooth, would roll on a surface perfectly level, hard, and smooth, *with the least possible resistance*, however great its weight, or the pressure on its rim.
- 6.—It therefore follows, that all the power that is employed in drawing forward a Cylindrical body, in a straight line, on a compressible substance, is ultimately applied in compressing, smoothing, and levelling the substance on which it rolls.

- 7.—The rolling of a Cylindrical body, therefore, can have no tendency to alter the relative situation or position of the parts of materials on which they pass, nor any how to derange them, but by a progressive *dead pressure* to consolidate, level, and smooth them.
- 8.—And the binding materials over which they pass being thus brought more within the sphere of mutual attraction, and into more perfect contact, are left in a state more favourable to concretion and induration; and, in every respect, better qualified to resist violence, and to protect from rains, the *softer materials* which they cover; and *they*, being thus kept dry, are the better enabled to support the crust that protects them.
- 9.—These properties of the Cylinder are practically confirmed by the effect which frequent rolling with a Cylinder has on gravel walks, it renders them compact, hard, smooth, and impervious to rains, and, consequently, secure against the devastations of hard frosts. Nor does it brake or grind the gravel.
- 10.—If a Cylinder be cut into several lengths, as represented in Fig. 1, each part will possess all the above properties; and if the rim of a Carriage-wheel be made exactly of the same shape it must necessarily have the same tendencies; and its rolling will have the same effect on the roads that Cylindrical rollers are observed to have on garden walks.
- 11.—When wheels with *Cylindrical rims* are connected by an axis, the tendency of each being to advance in a direct line, they proceed in this connected state with the same harmony and unity of consent that exist in the parts of the same Cylinder; with the same facility of motion (5) so favourable to the cattle; and with all other properties that have been stated as favourable to the roads. *There is no more*

more friction or resistance in this connected state of the pair of wheels that are applied to the same axis, than if each rolled separately or unconnectedly.*

- 12.—All these properties of the Cylinder depending wholly upon the equality of every part of its diameter, are peculiar to it; and it is impossible to gain equal advantages with any other shape of the Circumference of a Wheel.†
- 13.—But as Conical Rims have been universally preferred for a series of years, it is natural to suppose that there were obvious reasons for such preference. Let us then endeavour to investigate the Properties that must necessarily arise from the shape of the Cone; and see from them how far the consequent effects can justify the preference so long given to the Conical Rim.
- 14.—THE CONE diminishing gradually from its base to its point, the velocity of every part of its circumference in rolling on an even plain will be diminished as the diameter, and at the very point, where there is no visible diameter, there is no perceptible motion, the Cone revolving round it, as a fixed point or centre; we shall therefore, call it the *Conical Centre*, to distinguish it from the Axis of the Cone.‡
- 15.—Let a Cone have races or circles marked on its circumference, dividing the whole length into ten equal spaces, as represented in Fig. 2; if it be made to roll on a smooth regular horizontal surface, the circles that are on the circumference of the Cone will trace on the ho-

* The contrast to this will be seen when we consider Conical wheels applied to an Axis.

† The Globular is the only shape that can advance in a straight line with the same facility that the Cylinder does, but the Globular form rolling on a flat surface, touches only in a point; and in rolling on compressible substances, it partakes of the disadvantages of the Cone: whereas the Cylinder bears equally on the whole breadth of its rim; which gives it superior advantages for the wheels of carriages.

‡ In treating of Conical wheels, the *Conical centre* is only an imaginary point, and must not be mistaken for the centre of the wheel, which is the Axis of the Cone.

horizontal

horizontal surface other circles, also at equal distances, the circumference of each representing the space described by the part of the Cone that passes over it in one revolution round the Conical centre, and the comparative spaces in any number of revolutions.

- 16.—But the circumference of each circle is as its distance from the centre, and the velocity of each part of the Cone is also as its distance from the centre (14); therefore the space described by each part of the Cone in rolling round its point is as the velocity of such part; and the Cone will roll *in this direction* with the same facility that the Cylinder does in a straight line (5).
- 17.—But if the Cone be made to advance in a straight line, the natural velocities of its several parts will *not* be as the spaces which they are compelled to advance (16); therefore a rubbing and friction will take place at its circumference, which must render the draught heavier.
- 18.—Let a straight line be drawn from the centre of the circles in Fig. 2, to the circumference of the largest, and divided into a number of equal parts, suppose 100 and numbered progressively from the centre, A. to D. Each part of this scale will express the velocity of that part of the Cone that rolls immediately over it; and thus may be found the difference of velocity of any two parts of the Cone (16).
- 19.—EXAMPLE: If the difference of velocity of the greatest and the smallest parts of the circumference of that piece of the Cone which is marked No. 10, be desired; the scale shews the velocity of the greatest part to be 100, and the least part 90; and if each part was to advance according to its natural velocity (16), the greatest would run ten miles whilst the smallest part would only advance nine; which, in fact, happens when they roll round the Conical centre;* but, *when made to*

* This may be seen by the scale A. B. which shews the comparative spaces described by the different parts of the Cone in any number of revolutions round its point or Conical center A.

advance in a straight line, the smallest part of the rim is necessarily dragged one mile in ten, to keep pace with the largest part.*

20.—And if the Cone be supposed to be cut, and separated at the several races marked on its circumference, and each part to form the rim of a Broad wheel; the separated parts will regard their Conical centre as when united with the others. And the difference of velocity of the parts of each wheel, and consequently, the friction and resistance at its rim, when advancing in a straight line, may easily be determined. And it will clearly appear that the rubbing at the rim of each, will in passing through a given space, be increased as its diameter is diminished (19), and its breadth is augmented.

21.—EXAMPLE: In the part of the Cone marked 5, the greatest velocity is 50, the least 40; so that with these velocities the larger part of the wheel would advance five miles, whilst the smaller would only advance four (16); but, *when moving in a straight line*, the smaller part of the Conical rim must necessarily advance as far as the greatest part does, and must consequently be dragged *one-fifth of all the way it goes*.

22.—If we take yet a smaller part of the Cone, No. 3, its greatest and least velocities are to each other as 40 to 30, or as 4 to 3; so that a wheel of this shape and proportion must have the smallest part of its rim drag on the surface of the road *one-fourth* of all the way it goes; and daily experience shews how much the *dead drag* of one wheel retards the progress of a carriage; and by analogy, we may judge of the effect of a constant, although partial drag, on all the wheels of a heavily loaded waggon.†

23.

* If the numbers on the scale A. B. be reversed as at A. C. they will express, in decimals of the whole progress (15), the quantity of dragging at every part of the Cone; when advancing in a straight line, and rolling according to the natural rotatory velocity of the largest part of it.

† If a waggoner was compelled by any regulation to travel with one wheel constantly dragging, he would willingly pay an ample consideration to set it

- 23.—But the evil arising from this rubbing at the rim of Conical wheels is not confined to the increased labour of the cattle only; the *greatest efficacy is also given to their increased exertions* in destroying the hardest and most valuable materials of the roads: the largest part of the wheel dragging forward the smallest; and it, with equal force resisting; there arises an action and a counter-action, and the largest and the smallest parts of the rim advancing with different velocities, and pressed by the weight of a heavy load, become alternate fulcrums to each other, for the destroying and grinding the hardest materials that can be procured.
- 24.—Whoever takes the trouble of inquiring into the requisites of a well-constructed pulverising mill, will find them combined in the Conical broad wheel of a heavy-loaded waggon.
- 25.—The impalpable powder that is thus formed on the surface of the roads, when in a dry and rigid state, is, by the least agitation, raised into clouds of dust, to the great annoyance of the Traveller, and all who live near the road; to remedy which in some degree, watering is used near the metropolis; which, keeping the roads moist, they more readily admit water, which anticipates and increases the effects of wet seasons.
- 26.—When the roads are more moist and compressible, the effect of the *Conical rim* is altered, but not less destructive. On the approach of wet seasons, the body of pulverised matter that lies upon the more solid gravel which resists the wheels, is soon mixed with water, and forms a body of sludge which excludes air, and keeps the roads in a

it at liberty. And if he were aware that each Conical rim has a partial constant drag, it cannot be doubted that he would gladly be relieved from this unnecessary labour of his Cattle, by altering the shape of the rim, and submitting to such regulations as must ultimately tend to the improvement of the roads, and to his own immediate advantage, by relieving his cattle from unnecessary exertion.

constant

constant state of moisture. This soon renders the interior parts of the road so pliant that the pressure of a heavy Waggon wheel will make the whole breadth of *its Conical rim* to apply flatly, and press hard upon the more solid materials which lie under the sludge; the parts of which being now in a state more susceptible of altering their relative positions, comply with the motion of such parts of the wheel as immediately press upon them; and the relative situations of the parts that form the Crust of the road, is as much altered among themselves as the velocity of the parts of the rim differ from each other (21, 22); and thus, all former concretion is destroyed, induration prevented, and the materials which form the crust of the road left in a broken unconnected state, ready to imbibe the water which the sludge on its surface supplies constantly and abundantly: and by this means the most destructive effects of wet seasons and subsequent hard frosts are introduced in a manner as effectual and certain, as it is deeply concealed from observation.—How different is this from the consolidating effects of Cylindrical rims under the same circumstances!

- 27.—IN ROLLING ON PAVED STREETS nothing can be conceived more calculated for their destruction than the *Conical rim* of a Broad wheel. Let us suppose the *largest* part of the circumference of the Broad wheel of a Waggon to bear upon one stone of the pavement, and the smallest part of it upon the adjoining stone, the one will be pushed backwards and the other dragged forward (23) by the force of the horses that draw the Carriage: and if this force is sufficient to open the joint between them so as to admit water, the mischief is done; a wet joint will imbibe more water; this softens the gravel with which the paving is laid; and leaves it less able to resist the next effort; by which the joint gets more loose, and admits water sufficient to *float* and *discharge the gravel*; which ultimately undermines the paving, and furnishes the surface of the streets with that copious supply of new dirt, which
may

may be seen very soon after it has been completely washed by heavy rains.—This effect of Conical wheels acts in so latent a manner, that it appears to have totally escaped notice; *but the Cylindrical rim will not only prevent all this mischief, but will also improve the streets*, by producing the effect of the Rammer wherever the wheel passes.

- 28.—Several other disadvantages of less importance attach to the *Conical rim*; a constant divergency from the rectilineal direction, makes the wheel to press continually against the linch pin, and ready to fly off the axis when the linch pin is lost or broken (20). The same divergency occasions a twisting of the Nave on the Axis, which increases friction. And if the Nave is gulled or badly fitted on the Axis, it will occasion the hind part of the wheels to run closer to each other, than the front, which makes it rub hard against the *inside** of deep ruts, and throw up much dirt towards the middle of the road, none of which inconveniences attend the Cylindrical rim.
- 29.—It may be thought extraordinary that no good quality should there have been imputed to the Conical shape of a wheel, although sanctioned by universal preference for so many years: but if any do belong to it, except only the flat bearing of its whole breadth, the Author of this Essay has not been so fortunate as to discover them. He will, in a subsequent part, attempt to shew the reasons that first introduced them, and that occasioned the preference so long bestowed on them; but it would here divert the attention from what is of more moment to the immediate inquiry.
- 30.—Let us then, to assist the memory, and to bring the comparative merits of *Cylindrical* and *Conical rims* into one point of view, briefly recapitulate the properties that *inseparably* belong to each: and first of

* *Inside.* Here means the side next the Carriage.

THE CYLINDRICAL RIMS.

1. Naturally advance in a straight line (3) ;
2. Have no friction or rubbing at the circumference (4, 5) ;
3. No rubbing against the sides of deep ruts (11, 28) ;
4. No throwing up of dirt by the hind part of the wheel (11, 28) ;
5. Do not increase friction on the Axis (3) ;
6. Have no pressure against the linch pin (3) ;
7. The only resistance to their rolling in a straight line is from compressing, smoothing, and levelling the substances on which they roll (5, 6) ;
8. They have no tendency to displace, derange, break the texture, or retard the concretion and induration of the parts on which they roll (7) ;
- 31 { 9. Their frequent rolling on compressible substances renders them more compact, smooth, hard, and impervious to water ; and leaves them in a state more favourable to concretion and induration ; and, by keeping the *interior* and softer parts dry, *they* are the better enabled to resist violence, and to support the crust that protects them (7, 4) ;
10. They have no tendency to open the joints in paved streets (27) ; but, on the contrary, to improve them by producing the effect of ramming the stones on which they pass, by the *dead pressure* produced from the uniform velocity of all the parts (7) ;
11. And they advance *in a straight course* with the least possible resistance (5), and with advantages superior to any other possible shape (12).

These properties are as favourable to the preservation of the materials, and improvement of the Roads, as they are inseparable from the Cylindrical shape.

CONICAL RIMS.

1. They naturally roll in a circular direction, round their Conical centre (14, 20);
 2. A constant force is required to confine them to a straight course (17);
 3. When constrained to move in a straight direction a rubbing and friction take place at the rim (17 to 22);
 4. They increase friction on the Axis (28);
 5. They occasion a rubbing against the sides of deep ruts (28);
 - 32 { 6. And a throwing up of dirt from the hind part (28);
 7. In dry weather they pulverise the best materials (23);
 8. Which occasions much fludge in wet (26);
 9. In a compressible state of the roads they derange and break the texture of the parts, and leave them in a state ready to imbibe water, which introduces all the ruinous effects of wet seasons and severe frosts (26);
 10. They promote the destruction of paved streets and causeways, by forcibly opening the joints and admitting water under the stones, which ultimately floats and discharges the gravel, loosens the stones, and sinks the pavement into holes (27).
- 33.—*Such are the effects that unavoidably arise from the Conical shape, and they seem as much calculated for the destruction of the roads as those of the Cylindrical are for their preservation.*

34.—And, seeing that the Cylindrical Rim is the most favourable that can possibly be adopted for the preservation of the roads (31), and that the Conical is the most destructive (33), a certain advantage must be gained by using the former instead of the latter; and as this advantage must be in proportion to the space that is rolled; it cannot be thought excessive to rate that difference at one shilling for every Acre of road that is rolled with an improving roller, instead of an impairing one. Let us then see what may be the probable amount of the advantage that may thus be gained to the nation yearly, by adopting Cylindrical Rims for the Wheels of such waggons only as travel the Turnpike roads.

35.—The number of waggons in England is upwards of 96,600; and supposing that a tenth only of that number is employed on the Turnpike roads; and a fourth of that tenth, or a fortieth of the whole, have wheels twelve inches broad; and of the remaining three-fourths, that one half have wheels six inches broad, and the other half, wheels only four inches, the statement of the whole will be as follows*:

36.	Number of Waggon employed on the Roads	9,660
	Waggon with 12 inch wheels	2415
	Ditto with 6 inch wheels	3622½
	Ditto with 4 inch wheels	3622½
		— 9,660

37.—A wheel 12 inches broad, will in rolling thirty miles, cover a space of 158,400 feet, and the four wheels of a waggon will, at the same rate, in a day's journey, roll a surface of 633,600 feet, which is

* Allowing 9,660 Waggon to travel the turnpike roads, there remains 86,940 of which notice will be taken hereafter.

equal

equal to the whole surface of four miles of a road thirty feet wide; and something more than fourteen and a half acres; but rejecting fractions, and taking fourteen and a half acres as the quantity, the result in acres will be as follows:

	Acres.
38. 2415 Waggon, with 12 inch wheels, will, in a } day's journey of thirty miles, roll . . . }	35,012
3622 Waggon, with 6 inch wheels, will roll . . .	26,259
3622 Waggon, with 4 inch wheels	17,506

The number of Acres rolled in a day by all the Waggon }	78,777
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39.—And supposing all the Waggon, at an average, to travel only ninety days in the year, they will roll a surface equal to 7,089,930 Acres; which, at one shilling per Acre. will exceed THREE HUNDRED AND FIFTY THOUSAND POUNDS per Annum.

40.—But waving pecuniary estimates; let it be remembered, that the quantity of surface that is rolled once yearly by the waggon that travel the roads of England, is equal to the *entire surface* of 1,948,880 miles of road thirty feet wide (37, 38). It is then of importance to inquire, whether the wheels that roll it tend to improve or to impair? *

* It is to be observed, that no notice is here taken of the Waggon that are supposed to be employed for the purposes of Agriculture, &c. nor of the immense number of Carts, Coaches, &c. that travel the Public roads.

41.—The sovereign power of prejudice established by long usage, and universal adoption, would forbid an attempt to prove the unfitness of Conical rims, if a desire of rendering a public service, and a knowledge of the abilities and dispositions of many Members of both Houses of Parliament to promote improvement, and their unwearied attention to the good and comfort of the public, did not demand it as a duty, and afford every reason to hope that if any thing here offered is deserving their attention, it will receive ample discussion, and that such regulations may be adopted, as will introduce a general and voluntary use of Cylindrical Broad-wheels to all such Waggon and Carts as travel the Turnpike roads: and that may, not only introduce such wheels, but also diffuse the effect of their rolling more equally on every part of the surface; by which means the roads in this country may be improved, without additional expence, to a degree much exceeding general expectation.

42.—And with a view to remove such prejudices, *we now proceed to shew, that, in the early state of wheel carriages, CONICAL RIMS were introduced as matter of accommodation without any attention to the immediate and destructive effects which they have on the roads.*

It is pleasant to look back and view the primitive state of the roads and carriages in this kingdom, and trace the gradual improvements which they have undergone within the last half century, and the increase of wealth, comfort, dispatch, and additional time for business, which the inhabitants of the kingdom enjoy from the improvement of the former, and the increased number of the latter.

43.—SLEDGES probably were the first Carriages used; and, as an improvement on these, wheels were applied, to diminish the friction on the surface of the roads.

- 44.—The first wheels that were applied to Carriages were *fixed on the Axletree*, which turned with them, so that the Axis must necessarily be straight, and the wheels at right angles to it, and parallel to each other; and to give the whole breadth of the rim an equal bearing on a flat surface, *it must necessarily have been Cylindrical.*
- 45.—In remote parts where many concurring circumstances retard the progress of improvement, these original carriages may yet be seen; and an attentive observation of the primitive state of the roads as well as of the carriages may throw much light on the subject of this inquiry.
- 46.—The narrowness of the roads in their early state made it necessary that the wheel Carriages also should be narrow; and it is more than probable, that the Carriages first used were only for the purposes of husbandry, and drawn by one horse.
- 47.—But in process of time it was found expedient to enlarge the Carriages, and to increase the number of horses; but the narrowness of the roads, and the depth of the ruts that were already cut in them, made it necessary that the wheels of the new Carriages should run in the tracks of the old.
- 48.—To gain the advantage of a wider carriage without making the wheels run wider, it became necessary to alter the original construction: The axletree was now fixed immoveably to the body of the carriage, and the wheels made to turn independently on *its ends, which were made to incline, or bend, downwards*, by which means the wheels stood wider, or further apart at top than at bottom; and thus, room was gained for the body of the carriage without altering the track of the wheels.

- 49.—The Axis being for this reason *bent* (48), and the wheels no longer standing parallel, it was necessary, in order to gain a flat bearing of the whole *Rim*, to shelve it off towards the outer edge, as much as the ends of the Axis were bent from the straight line (48); and *thus, the Rim became Conical*. Nor is it probable that any distinction was then made between the flat-bearing of a Conical rim, and of a Cylindrical rim of the same breadth.
- 50.—When the wheels were made to turn on the ends of the Axis in order to get a steady motion of the carriage, a longish socket was put in the centre of the wheel, so fitted as to receive the end of the Axis, and to turn on it freely and without shake. This socket is called the Nave, and has all the spokes, or radii, inserted in it.
- 51.—The wheels now diverging at top, the spokes were inserted obliquely into the Nave, so as to stand perpendicularly *when directly under the Axis*, the better to sustain the weight of the load: and this oblique position of the spokes, ~~giving to the side of the wheel farthest from the carriage, a concave appearance,~~ is called *Dishing*: and thus it clearly appears, that *the bending of the Axis occasioned both the Conical rim (49) and the dishing of the wheels (51)*; and as both were mere matters of accommodation, adapted to the then existing state of the roads, the narrowness of which, demanded a bended axle (49), there is no great reason to believe that the bad qualities of the former, nor the advantages of the latter, were originally adverted to.
- 52.—In process of time it was observed that *dishing* added much to the strength and stiffness of wheels, even with very light timbers; and, on attentive examination, this construction was found to embrace all the properties of an arch.

53.—The bended Axis necessarily demanding a Conical rim (49) and a dished wheel (51), they were considered as inseparably connected; and the advantages of dishing were considered as peculiar to the Conical rim, which circumstance, together with an inattention to its destructive effects which it had upon the roads, have probably been the only reasons of *its* being so long and universally preferred to the Cylindrical shape.

54.—But the *dishing* is by no means peculiar to Conical wheels, and is equally applicable to Cylindrical: and the advantages arising from this Arcular construction of the wheel, is, in some cases, applicable in a greater degree to Cylindrical Broad wheels, than to Conical.

55.—*It does not then appear that any preference is due to the Conical Rim on account of the advantages that arise from the dishing the wheels, since they are equally applicable to Cylindrical wheels. And, as none of the immediate properties or effects of the Conical wheel entitle it to a preference, let us inquire whether there are any concomitant circumstances that can recommend it; or forbid the use of the CYLINDRICAL SHAPE.*

56.—The adoption of a Cylindrical form will necessarily require a *straight Axis*, (44) and no other alteration whatever in the construction of the carriage will be necessary. But as the straight Axis would make the wheels run equally wide at bottom as at top, the Axis must necessarily be longer, and the track of the wheels wider, to preserve the same room for the body of the carriage,

57.—We are therefore, to inquire whether, independent of the immediate effect which the rim of the wheel may have on the road, their running wider on it may be hurtful, on a more general view of all circumstances?

58.—By making the wheels run further apart on the road, the base on which the carriage stands becomes broader, and consequently it is not so easily overturned: and in passing over obstructions, irregularities, or roughness on the roads, the agitation of the *centre of mean resistance* will be diminished, as the distance of the wheels is increased; and the resistance arising from the *vis inertiae*; the fatigue of the rider; and the labour of the horses, will be diminished in the same proportion: all which considerations furnish additional motives for preferring the Cylindrical wheel and straight axis.*

59.—Having thus totally failed in discovering any one argument in favour of the *Conical rim*, let us endeavour to shew what has so long concealed its *destructive effects*; more especially, as universal preference was given to Cylindrical garden rollers.

60.—First, The garden roller being worked by men, and used singly, the difference of the natural tendencies and effect of the Cylinder and of the Cone, were more exposed to observation, and more easily distinguished, than when wheels are connected by an Axis (64). In drawing the

* Much depends on a thorough understanding of this principle in the construction of wheel carriages, especially those for dispatch; and in constructing and loading ships. And there are not wanting instances where, from a want of due attention to this principle, one half of the effect in mechanical operations is totally lost, and the labour doubled.—The *centre of mean resistance* in carriages and in navigable vessels is nearly allied to the centre of oscillation in Pendulums; but involves more considerations; and its application to wheel carriages would, in some instances, appear to be directly contrary to what it is in nautical concerns. In wheel carriages all deviations of the *centre of mean resistance* from the line of direct progress, are either horizontal or vertical, or compounded of both.—Deviations generally increase resistance; but in some instances vertical deviations may be promoted to advantage, but the horizontal never; and every circumstance that tends to prevent or diminish them is advantageous in the construction.

Conical roller on a straight walk, its strong bias to deviate from the *straight direction*, and the very considerable and constant exertion necessary to compel it to advance in a straight line could not possibly pass unnoticed.

61.—Secondly, The rubbing and grinding of its smallest end, and the much greater exertion necessary to draw forward the Conical than the Cylindrical roller, must engage the attention of every rational being employed to draw them.

62.—Thirdly, And that such has been the case is evident from the constant and universal preference given to the Cylindrical garden roller.— And although the Conical roller demands much more force to draw it forward, it never leaves the surface so close, compact, and smooth, as the Cylinder does, the smaller end of the Cone rubbing and dragging on the surface leaves it rough, loose, and unconnected. All which circumstances could not possibly escape the notice of the most ignorant or inattentive person whose bodily exertions were employed in drawing them; and whose attention was directed to their effect.*

63.—It might be thought that the superiority of the Cylindrical over the Conical garden roller might lead to an investigation of the comparative merits and effects of the Cylindrical and Conical wheels of carriages, but *the following circumstance has probably prevented it, by concealing from observation the real and natural tendency of the Conical Rim, and consequently its destructive effects.*

* The improving qualities of the Cylinder are much more obvious than the destructive effects of the Cone, which, in a great measure, accounts for the universal preference given to the former for garden rollers, and the readiness with which the latter shape was used to the wheels of carriages, when it was found convenient to have a bended axis (49).

64.—When a pair of Conical wheels are applied to an Axis, they advance in a straight direction, APPARENTLY with the same ease and tendency that Cylindrical wheels do (11). But how deceiving is this appearance, may be seen by an attentive perusal of what is said from paragraph (15) to paragraph (23); each wheel constantly endeavouring to roll round its Conical centre; the one drawing to the right; and the other, with equal force, drawing to the left; they exactly counter-act each other, and are thus compelled, to advance in a straight line. But although this rectilinear progress *appears to be natural and spontaneous*, it is quite the reverse;—the natural tendency which so powerfully presses itself on the notice of him that draws the single Conical roller (60) is here concealed by the intervention of the Axis.—The two Conical wheels counteract the divergency of each other; but the *destructive effect of each wheel on the roads, and its resistance to the draught, is in no degree diminished*, although deeply concealed from observation.—*And these reasons seem to account sufficiently for the evils arising from the Conical rims having so long escaped detection*: for if waggons, like garden rollers, had been drawn by men, the increased exertion required with the Conical rim would soon have engaged their attention, and independent of all other considerations would have procured to the Cylindrical waggon wheel, that preference which was so justly bestowed on the Cylindrical garden roller.

65.—But it may be necessary to add some further reasons for being of opinion, that the bad effects of Conical rims were either totally unobserved, or have remained without due investigation.

66.—The strongest argument that has been offered for continuing the Bended Axis, is, “That when the Axis is straight its Conical ends act in
“the Nave of the wheel as on an inclined plane, which gives it a
“constant

“ constant tendency to press against the lynch pin, and to throw the wheel off the Axis.”—The remedy proposed was “ to make the Axis so that the *under side* of its Conical ends shall lie in a straight line.”—This necessarily demands a Conical rim, and plainly proves that they were not aware of the divergency that arises from it. For thus, *by bending the Axis, there is a necessity of making the Rim Conical* (49); and the Conical rim, unavoidably occasions a strong and constant pressure against the lynch pin (64), so that in attempting to remedy a small imperfection at the centre; they not only increase the very imperfection which they meant to remove, namely the pressure against the lynch pin, but also add another, and much greater evil, at the circumference of the wheel (22); which cannot be removed *by any possible means* but by rendering the Axis straight, and the Rim Cylindrical.—This demonstrably proves, that the tendencies and effects of the Conical shape were not attended to by the advocates for the Bended Axis.

67.—Another strong ground for believing that none of the bad effects which attend the Conical wheels have been attended to, arises from the great mechanical skill and heavy expences that have been bestowed in removing or diminishing the friction on the Axes of wheel carriages; which, when compared with the friction at the circumference of the Conical wheel, is totally undeserving of notice, from the very trifling comparative resistance which it occasions.*

68.—And, moreover, the natural friction on the Axis may be much abated by the application of oil, grease, &c. but there is no possible remedy for the friction, trituration, and increase of resistance that unavoid-

* Admitting the rim to be perfectly flat, smooth, round, and hard: and that the plane on which it rolls is equally perfect and truly horizontal.

ably take place at the Conical rim, but by substituting *the Cylindrical rim*.—All which concurring circumstances, it is presumed, may justify the opinion, that the Cylindrical and Conical rims have been indiscriminately used, without attention to any properties peculiar to either: always preferring that rim which admitted of a flat bearing of the whole breadth of the wheel (44); and consequently when the *Axis* was straight, the Rim was Cylindrical; and with the bended *Axis* the rim was necessarily Conical (49).

- 69.—It appears then, that in searching for arguments in favour of the Conical wheels, we meet with nothing but additional reasons for preferring the Cylindrical; and as the Bent *Axis* and Conical Rims were first used on account of the narrowness of the roads (48, 49) there can be no reason, at this time, for continuing the use of them for such carriages as travel the turnpike road only.—And the advantages which must result from the use of Cylindrical wheels to them alone, will be more numerous and extensive than they have hitherto been stated (58), arising from considerations that are not within the scope of our present inquiry.
- 70.—In the foregoing Estimate (39), no allowance was made for such waggons as are used in agriculture, and seldom come upon the public roads: but as every improvement of the private as well as public roads must be a national benefit, we shall now consider what advantage may be gained on the private roads by the same means.
- 71.—Eighty-six thousand nine hundred and forty waggons are supposed to be employed for the purposes of agriculture (35), which is nine times the number that use the turnpike roads; but as they do not keep constantly even upon the private roads, we shall suppose them to travel, only one day in a month, at which rate they will, *ceteris paribus*, roll more surface

face than all the waggons that travel the public roads, at the rate of eight days in the month; but let us suppose it only equal.

72.—The quantity of surface that is once rolled yearly, by all the waggons on the turnpike roads, is equal to the entire surface of 1,948,380 miles of a road thirty feet wide (40), and taking an equal quantity for the private roads (71), the whole surface that is rolled yearly by waggon wheels on the public and private roads together, if uniformly diffused, would cover every part of the surface of 3,897,760 miles of road thirty feet wide; and in proportion as the length of road on which this traffic is supposed to be carried on is shortened, so much the oftener would it be rolled.

73.—The circumference of the globe is computed at about 24,900 miles, and taking it at that measure, the number of miles at 30 feet wide, rolled yearly by the traffic of waggons only, in England, would reach round the globe 150 times; or if a road 30 feet wide was made round the globe, the traffic of waggons in this kingdom would roll every part of its surface 150 times in a year (72): and if two such roads were made, it would roll the entire surface of both 75 times in the year. And,

74.—Supposing such roads made close to each other, and in every respect similar, as to formation, materials, exposure, &c. &c. But that the one is rolled by Cylindrical, and the other by Conical wheels, 75 times in the year, the former will be rendered more compact, close and impervious to water, each time of rolling; and in the end, will be so solid and hard, and its surface so close and smooth, and so free from sludge, as neither to admit, nor to lodge water; which is the most effectual means possible of guarding against the destructive influence of wet seasons and severe frosts (31).

75.—But the *other road* being rolled also 75 times, with Conical wheels, they will in dry seasons, pulverise and destroy the best materials intended for the protection of the roads (23) ; and, in wet seasons, they alter the arrangement and destroy the texture of the component parts of the crust, and leave them in a broken unconnected state, ready to imbibe water (26), which is constantly supplied by the sludge on the surface ; which also effectually excludes the sun and air ; and thus, the roads become rotten, and break into holes and ruts ; and if a rainy autumn is succeeded by severe frosts, they will raze to the foundation every part into which water has penetrated.

76.—Let any man of observation, who has had an opportunity of attending to the nature and repair of roads, and the expences attending such repairs, seriously consider all the above circumstances, and make his own estimate, of the number of men ; quantity of new materials ; and extent of labour and expence that would be yearly necessary, but more especially after a wet autumn and severe winter, to restore that road that had been rolled by Conical wheels to an equal state with the road that was rolled with Cylindrical wheels, and he will, probably, make it to exceed what has already been stated (39).

77.—It is also to be observed, in addition to what has been said, that the latter part of the road will not only be much more expensive than the former, but is liable for some months in the year to be in a state very disagreeable, and even dangerous to the traveller ; and very destructive to the cattle ; and at no time so pleasant as the road that is rolled with the Cylindrical wheels, on account of the dust in summer (23), and the deep sludge in winter (26). And the draught of carriages upon it is at all times, but more especially after repairs, much heavier than upon *that road, which remains unimpaired* *.

* It has been observed, that where running waters have accidentally covered the surface of the roads, they were consolidated and improved thereby ; this

78.—When the advantages of Cylindrical wheels are fully proved, and universally known, there is no doubt, that thin, light, smooth rims, truly Cylindrical, and broader than are now used, will be adopted universally for Carriages of pleasure and dispatch, as well as for those of burthen; which, considering the immense number of Carts, Coaches, &c. &c. &c. in this kingdom, will add greatly to the advantages already stated: and the saving that must arise in the repairs of private roads, from the use of broad Cylindrical wheels, will very soon repay the first expence of making them of a sufficient breadth to admit carriages of any dimensions, which will totally obviate the only reason that now exists for using a bended axis and Conical rim (46 to 49), and pave the way for an universal adoption of a straight axle and Cylindrical wheel.

79.—The Author of this Essay is conscious that more is already said than is necessary to enable men of extensive information and quick conception to form their judgment; and although he is aware, that the success of this attempt will wholly depend on their opinion, example, and support, he is nevertheless anxious to convince others, who are more immediately interested, but whose opportunities and capacities are more limited.—It will not be denied, that rolling with heavy Cylin-

introduced the practice of washing them, where water can be procured, which is found very beneficial; but daily experience shews the advantage of removing sludge by other means where running waters cannot be procured; and, although several reasons might be offered, why sludge is more penetrating and hurtful to the roads than water, such enquiry being foreign to our subject, it is sufficient for our purpose, that daily experience and observation confirm the fact: if then, the removal of sludge from off the roads be so advantageous, surely any means by which its formation and accumulation may be prevented or diminished would be yet more advantageous; and this can best be effected by discontinuing the use of Conical wheels; which will diminish the dust in summer, the sludge in winter, and save the most valuable materials that incrust and protect the roads.

drical

drical rollers would even in the first instance much improve the roads ; but the expence attending this operation would exceed all reasonable bounds.—Let us then inquire, to what degree it may be accomplished without additional labour ?

80.—If the breadth of Cylindrical wheels is made to bear a regular proportion to the number of draught horses ; and the fore-wheels to run narrower than the hind, so as to roll a double surface ; and proper regulations are made for quartering the roads ; every waggon might be made as effectually to improve that part of the road on which it rolls, as if the horses had been employed for that only purpose : it is true that the rollers in this case are not so broad as might be desirable, but if the effect is not so extensive, it is more dense and compressive ; and if the roads are made so nearly flat, that carriages may with equal conveniency drive on every part of them, they will be more equally traversed, and more uniformly improved than at present ; the destructive effects of the Conical wheel will be evaded ; and the draught of the horses made much easier.

81.—Let us now see what sum would pay for the labour of the horses that may thus be made to roll the roads gratis, if they were employed for the only purpose of rolling them ?

The number of waggons supposed to travel the turnpike roads is 9,660, and allowing three horses, at an average, for each waggon, their number will be 28,980 ; and taking an equal number for those waggons that use the private roads (72) the whole number will be 57,960 ; and supposing them to be employed only 90 days in the year, at 4s. per day for each horse, it would amount YEARLY to upwards of ONE MILLION STERLING.

It is not meant to assert, that any of the estimates here offered are correct; but it is hoped they prove, that in every point of view, the object is of such magnitude and importance as to claim attentive investigation; and if what has here been advanced is found to merit the notice of those to whom it is addressed, Mr. CUMMING will consider himself as peculiarly fortunate in having suggested an improvement, from which, every individual in the kingdom may derive accommodation, without expence to any; and by which, ultimately, a very considerable yearly saving may be made to the Public.

POSTSCRIPT.

IN the foregoing Essay, the conclusions are drawn from facts, and practical observations only. The Author of it was for many years, in the earlier part of life, in the habit of reading all publications on subjects of this nature, and all others relative to Mechanical and Philosophical improvements; but of late years he has seldom found the information which he could glean from compilations, to compensate for the drudgery of reading them; for this reason, he has for several years past, seldom read periodical publications: and if any thing relative to the subject of the foregoing Essay has been published in that way, or in any other, it has escaped his notice: but he will thankfully receive any information on the subject that can lead to improvement.

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